Silvicultural Lessons From the December 2000 Ice Storms

by

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Abstract

In December of 2000, two destructive ice storms covered Arkansas, affecting 40% of the state's forestlands. Damage estimates ran into the hundreds of millions of dollars, with much of the loss occurring in loblolly pine (*Pinus taeda L.*) plantations. A study was initiated in south-central Arkansas to track the recovery of damaged trees on these plantations. Over 400 survivors were assessed for the type and degree of damage, tagged, and then re-evaluated after one growing season. Observations indicated that small diameter trees were more likely to bend severely, while intermediate size stems tended to break, and the biggest trees primarily suffered crown and branch loss. Though most individuals weathered this first growing season after the ice storms, the mortality (10%) was greater than what would be expected for comparable undamaged trees in managed plantations. Growth rates during this first growing season were a function of initial size and extent of damage. Overall, survivors averaged 0.2 inch of diameter growth, with over 10% exceeding 0.5 inch. The relatively high survivorship of even severely damaged loblolly pine suggests that salvaging of living trees may be postponed at least one growing season if fire, insect, or disease danger is not excessive. Individuals that received low to moderate damage appear capable of respectable growth following ice damage. Ultimately, it may prove more economical to partially salvage a damaged stand if sufficient stocking remains to meet management objectives.

INTRODUCTION

Ice storms are relatively frequent visitors to Arkansas. Depending on location, between 5 to 10 damaging glaze events have occurred during the last quarter century. In December of 2000, two major ice storms damaged up to 40% of the 18.3 million acres of timberland in Arkansas and cost an estimated $547 million (Forgrave 2001).

Industrially-owned loblolly pine (*Pinus taeda L.*) plantations in the south-central portion of the state were heavily damaged by these ice storms. Loblolly plantations that were formerly dense stands and had been recently thinned were particularly susceptible. This vulnerability has been noted by other researchers (Nelson 1951, Shepard 1981). Other factors that may have contributed to the degree of glaze damage experienced include wood quality, tree size/age, and site conditions (Brender and Romancier 1965, Smith 2000).

While some attributes are difficult to adequately control so as to minimize ice injury, appropriate silvicultural techniques have the potential to limit damage (Zeide and Sharer 2002). We have initiated a long-term study on loblolly pines injured by the December 2000 ice storms to help determine appropriate silvicultural responses to glazing. This paper gives preliminary mortality and growth results of this study and provides a number of post-event treatment recommendations designed to minimize losses following severe ice storms.

METHODS

Study Area

Six 18- to 20-year-old loblolly pine plantations in Dallas (4 stands), Grant (1 stand), and Jefferson (1 stand) counties in south-central Arkansas were chosen for this study. All stands were owned by International Paper Company, and had been thinned once but not fertilized. Sites varied somewhat by location, but were on roughly similar terrain (flat to gently rolling slopes) of intermediate quality.

Sampling Design

In April of 2001, we selected 410 live loblolly pines with differing types and magnitudes of

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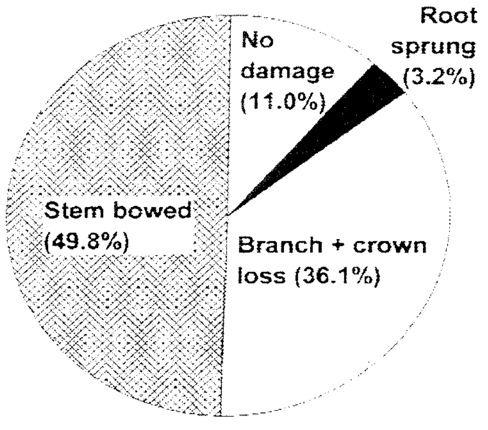
damage (Figure 1). Sample trees were not chosen randomly, but rather were picked as representative individuals expressing a range of damage for a given size class. Pines also were not selected in proportion to their size- or damage-class representation within the stand.

Figure 1. Distribution of sampled loblolly pines (n = 410) by damage types.



Due to logistical challenges, the loblolly pines in this study were not identified and measured until April 2001. Although limited recovery from the initial injury may have occurred for some of the stem-bowed trees in the intervening months, they still reflected the relative magnitude of the event. Damage ranged from very little lost tissue (e.g., limited loss of needles or small twigs) to the removal of most live foliage via branch loss or bole breakage. Loblolly that were bowed over or root-sprung were also included, but individuals broken below the live crown were not included because their death was inevitable.

Once selected, each tree was painted for later relocation and also received a numbered aluminum tag placed in the ground adjacent to the bole. Diameter at breast height (DBH) was recorded to the nearest 0.1 inch. For individuals that had been bowed over or root-sprung, an angle gauge was used to estimate the degree the growing tip had been bent from vertical (Appendix A), and a compass was used to estimate the azimuth of the lean. For trees with branch or bole loss, the percent loss of the crown was ocularly estimated to the nearest 5% (Appendix A). These measures were repeated after one growing season, with loblolly that died in the intervening period noted. Any other relevant damage attributes were recorded both during study establishment and at the first remeasurement.

Individual pines were then classified into one of five damage categories, based on their primary injury level (Table 1). The following results are based on this first-year assessment of the original 410 loblolly pines.

Table 1. Damage classification criterion.

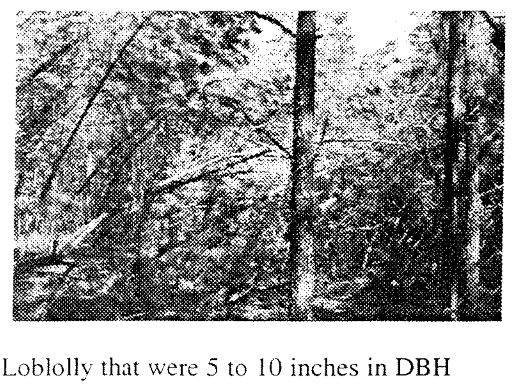
Branch/crown loss (%)	Category	Root-sprung/ bowing (°)
< 10	insignificant	< 10
10-24	minor	10-19
25-44	moderate	20-39
45-69	major	40-59
70-100	critical	60-90

RESULTS AND DISCUSSION

Damage Distribution by Tree Size

Patterns of glaze damage were not consistent across the DBH range considered. Small trees responded differently to ice accumulation than intermediate-sized individuals, which in turn behaved differently than larger pines. Although we did not specifically test for cause of breakage, this trend was probably related to bole pliability. Slender loblolly pines (mostly less than 5 inches in diameter) usually bowed under the weight of accumulated ice (Figure 2), but in many cases were sufficiently flexible to sustain this injury without noticeable damage to the branches, bole, or roots.

Figure 2. Ice damage to young loblolly pine, showing tendency of slender trees to bow.



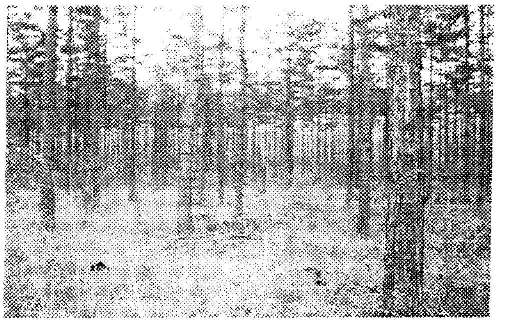
Loblolly that were 5 to 10 inches in DBH usually started to bend in a similar fashion, but the lesser flexibility of their stems, coupled with greater surface area, often led to stem breakage as the bending force exceeded the resistance capacity of the bole. Sometimes, the breakage was at a point in the crown where enough live foliage remained for the chance of recovery to be good. Others failed at a point along the bole where the entire live crown was lost, killing the loblolly pine outright (Figure 3).

Figure 3. Intermediate-sized loblolly pines tended to break along the bole, often below the live crown.

The largest of the pines (those greater than 10 inches DBH) usually had sufficient bole strength to survive these glaze storms with only the loss of a few branches or perhaps the growing leader (Figure 4). Since increasing size substantially increases the potential for resistance to ice damage, large trees will usually weather an ice storm better than small ones unless an aggravating circumstance (e.g., root disease or large canker) produces a critical weakness.

The extent of damage experienced by any given loblolly pine was a function of the particular circumstances of the individual. For instance, trees with asymmetrical crowns or forked boles often received more crown damage than more regularly formed individuals. Sometimes the leverage was sufficient to trigger root-springing, especially if the root systems were weakened or shallow.

Figure 4. With the exception of some branch and growing tip breakage, this older loblolly plantation experienced very little damage from the December 2000 ice storms.



First Growing Season Survivorship

Of the 410 living loblolly pines measured in April of 2001, 373 were still alive by the end of the first post-ice storm growing season. Almost 10% of the surveyed trees had expired either from their injuries or from subsequent causes like windthrown, insects, or disease. This mortality rate appreciably exceeded the expected loss rate for those stands if the ice storms had not occurred (K. Hansen, 2002, personal communication).

Generally, pine mortality paralleled their frequency in the original sample, suggesting that mortality was a function of damage severity rather than damage type. Of the 37 sampled loblolly pines that died during this period, most were individuals with pronounced crown loss or bowing (Table 2). Not surprisingly, undamaged loblolly pines suffered no

Table 2. Percent of mortality by damage type.

Damage type	Total no.	Pct. of total	No. dead	Pct. of total	Pct. of dead
branch loss	6	1.5	1	16.7	2.7
crown loss	142	34.6	13	9.2	35.1
stem bowed	204	49.8	16	7.8	43.2
root sprung	13	3.2	7	53.8	18.9
no damage	45	11.0	0	0.0	0.0
TOTALS	**410**	**100.0**	**37**	**100.0**	**100.0**

mortality after the ice storms. Losses were greater with damaged trees: 7.8% of bowed-, 9.2% of crown loss-, and 16.7% of branch loss-affected loblolly perished during this period.

One notable exception to the mortality trend occurred among the root-sprung pines. Root-sprung individuals comprised almost 19% of the mortality, yet represented slightly more than 3% of the original tree sample. Over half (~54%) of the 13 sampled root-sprung loblolly pines died, a much higher rate than any other damage type. The noticeably higher mortality of root-sprung individuals was probably related to the belowground damage experienced coupled with pronounced bowing of the trees. The likelihood of mortality increased with the severity of damage. No trees with insignificant to moderate damage perished in the first growing season since the ice storms, while losses in the critical category were particularly severe (Table 3). The magnitude of damage would suggest that root-sprung trees or those with leans greater than 60° or more than 70% of their foliage lost are poorly suited for long-term recovery and, hence, retention.

Table 3. Mortality rates by extent of damage following the first post-ice storms growing season (see Table 1 for category definitions).

Damage level	Total number sampled	Number surviving	Number dead (%)
insignificant	132	132	0 (0.0%)
minor	59	59	0 (0.0%)
moderate	45	45	0 (0.0%)
major	56	52	4 (6.9%)
critical	118	85	33 (28.0%)

Cursory examination of survivors in these stands after their first post-ice storm growing season suggests that mortality may increase sharply over the next few years, even for those that experienced only limited damage. By the spring of 2002, thinning crowns, chlorotic foliage, and abundant pitch seepage from bore holes on many survivors provided telltale signs of an insect attack that will probably claim many of the survivors. Disease problems are not as obvious at this stage but are also expected to increase.

First Growing Season Increment

Before being injured by the December 2000 ice storms, most crop trees in these 18- to 20-year-old plantations would have grown about 0.5 inch in DBH, depending on stand density and site quality (K. Hansen, 2002, personal communication). The widespread damage to their crowns has reduced this increment to an average of 0.2 inch for the survivors that displayed positive increment. Approximately 23% of the sample did not measurably increase in diameter during this first growing season, and 52% grew 0.2 inch or less.

However, not all loblolly that were sampled experienced poor growth. Almost 13% reached the 0.5 inch level, and a handful of trees exceeded 0.7 inch of diameter increment during this first growing season. For individuals that survived the glazing with relatively little injury, the ice storms acted more like thinnings than damaging events. This becomes apparent when injury magnitude is compared to diameter growth. When grouped by size categories, trees with greater damage experienced a disproportionately higher frequency of reduced diameter growth (Table 4). Table 4 also reflects the tendency of large individuals to survive an ice storm relatively unscathed.

Table 4. Number of loblolly pine survivors reaching the following growth rates by size class and level of injury.

Size class Damage level	Diameter growth ------(inches)------ < 0.2	 0.2-0.4	 > 0.4
	-- Number of survivors --		
< 7 inches DBH			
insignificant	8	20	1
minor	3	7	0
moderate	8	5	0
major	5	12	1
critical	22	7	0
7-10 inches DBH			
insignificant	11	54	9
minor	4	31	5
moderate	8	17	3
major	23	8	0
critical	41	13	0
> 10 inches DBH			
insignificant	2	18	9
minor	3	5	1
moderate	2	2	0
major	1	1	1
critical	0	2	0

MANAGEMENT IMPLICATIONS

Silvicultural practices recognizing that some locations and stand conditions are much more vulnerable to ice storms may provide the best strategy for managing damage. For example, Zeide and Sharer (2002) provided a number of preventive steps aimed at minimizing the risk of serious loss to glazing, including wide initial spacing, early thinnings, competition control, and designing management goals to local conditions.

However, most loblolly pine plantations are not managed with catastrophic natural disturbances in mind and need to be treated following a damaging event. A number of management recommendations for recovering from ice storms can be made based on these preliminary results. This list is not intended to be exhaustive, but rather to suggest the most productive strategies for recouping losses from ice storm damaged timber and preventing future losses.

1. Thoroughly assess the damage using a systematic inventory first, rather than believing the worst and assuming the stands are completely lost. Make sure the inventory recognizes the different types and magnitudes of damage possible, and realize that even moderately injured individuals still have considerable capacity to recover from glaze damage.

2. Keep stocking objectives in mind when deciding to replace or retain a plantation. Even when a large number of individuals from a stand have been lost to an ice storm, the residual stocking may be sufficient to manage as is, rather than clearing and beginning anew. If the crop trees are in reasonably good shape, understocked stands have the potential to recover to adequate levels by the end of the rotation (Baker and Shelton 1998).

3. If the markets are favorable, salvage the destroyed or critically damaged timber as soon as possible. Dead wood immediately begins to experience some loss of wood quality, and may be completely unsalable within a few months. Additionally, dead trees serve as a breeding and feeding ground for many damaging insects and fungi, which may quickly spread to survivors.

4. Loblolly pines that have received critical levels of injury (Tables 2 and 3) have a greatly reduced chance of surviving even the first year following a severe ice storm and should be targeted in any early salvage efforts. Their removal may also lend greater resistance to pest outbreaks in the stand, as these heavily damaged individuals are the least likely to successfully repel an attack.

5. Evaluate the long-term growth potential of injured but recoverable survivors. This study's early results suggest that even fairly heavily damaged loblolly pines can grow at a respectable rate, and unless severely damaged, may be indistinguishable from undamaged trees in a few years. Depending on the product being grown (sawtimber versus pulpwood or chip-and-saw), other criteria may need to be used. For example, if sawlogs are the desired product, and a young pine has been broken below the first log, then this tree probably should be removed.

CONCLUSIONS

Ice storms have the potential to cause serious damage to large portions of Arkansas forests, and, indirectly, the forest products industry. While their occurrence is unpredictable, careful adherence to good silvicultural practices before glazing strikes and quick thinking afterwards can help minimize the losses experienced by landowners.

This preliminary study of recovering planted loblolly pines following the December 2000 Arkansas ice storms has ramifications for post-event treatments. Critically injured pines (those with ~70% crown loss or ~60° stem bowing, or root-sprung individuals) experienced substantially higher mortality and lower growth potential, suggesting the value in their immediate salvage. Stands should also be watched for signs of expanding insect infestation, especially if salvaging has been delayed.

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Appendix A. Graphical examples of ice damage measurement protocols developed for the December 2000 Arkansas ice storm recovery study.